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TECHNIQUES AND MATERIALS FOR THE PROVISION OF MASS LOW-COST HOUSING AND ASSOCIATED FACILITIES

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No.431

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1. Introduction

(a) Just as the development of a country is dependent on the development of its natural resources and industrial activity, so also are these inherently dependent upon the development of the country's human resources. Good housing and the provision of spaces and buildings for use in education, health services and recreation are essential requirements in building up stable, healthy and industrious communities. It is obviously of prime importance, therefore, that the problems of housing and community facilities in a developing country should receive priority consideration.

(b) The development of countries in Africa has assumed astounding proportions during the past decade and the most extensive and urgent problems of housing are to be found in villages and towns where the rates of population increase have generally far outstripped any planned rate of urban growth. Settlement in the villages and towns has taken place, and continues to do so, regardless of whether housing and related amenities are available. New arrivals overcrowd already congested quarters or erect shacks, using whatever discarded or cheap materials are readily available, on any vacant piece of ground they come across, no matter how small this may be or how unfavourably it may be situated. Most often such dwellings are erected chaotically at high densities, so creating squatter shanty towns which offer little or nothing in the way of security, hygienic services or adequate amenities, and which consequently create breeding grounds for ill health, discontent, moral degeneration and crime.

(c) Furthermore, the problems in Africa are intensified because of the general

state of poverty amongst migrants to the towns[1]. In the first instance, the newcomers usually have no special skills which can earn them anything more than the lowest wages. New skills must be mastered and these often require long periods of training and experience. Previous outlets for providing the essential needs of the family can no longer be utilized; crowded conditions and lack of ground prevent these people from keeping animals or cultivating crops, even on a very restricted basis, and they can no longer build their houses on the traditional pattern as the required space and materials are not available. Secondly, their plight leaves them wide open to extortion by unscrupulous dealers and landlords. Unfortunately, even when the newcomers become adapted to urban living and their earnings increase, the change in emphasis from a rural economy to a largely monetary economy imposes on them their greatest problem, that of budgeting between pay days. Materialism as a status symbol in the form, for instance, of the possession of an expensive piece of furniture or of partaking in social amenities, often takes precedence over the provision of the basic necessities of life. Frequently, therefore, their deficiencies in housing, clothing, food and fuel remain with them for many years unless they are helped in some way.

(d) Whereas education and guidance are the only tools that can be used to teach people how to spend their money rationally on clothing, food and fuel, more positive assistance can be rendered by providing them with adequate housing at the lowest possible cost. This assistance should not be the sole responsibility of the local authority in each town or village; the work involved and the financial implications of providing satisfactory buildings on an extensive scale for housing, education and health services is, in most cases, beyond the capabilities of these authorities if they are left to act on their own. A national approach is therefore most desirable in helping to find solutions to the numerous common problems associated with overcrowding and slum conditions. In fact, it could be said that a national effort is a necessity, as slums are essentially a product of poverty, and in African countries poverty is not a localized problem but a national one. A national attack on the problems would also obviate the duplication of effort that would otherwise occur. A central body could organize and sponsor all research on the planning and technical requirements of housing and, from the data thus obtained: formulate standards for housing, town-planning and the provision of services; prepare specimen drawings and specifications; assist in developing the manufacture and use of building materials using local resources; introduce schemes for training the required labour forces; and provide a system for financing housing schemes.

2. The need for research

(a) In order to approach the low-cost housing problem intelligently and to establish policies on a sound long-term basis in the interests of a country's development, it is imperative that planning should be based on fundamental information obtained from investigation and research[2]. Such information must lead to planning that is both sound and economic. In some cases it may be possible to modify the research findings obtained in one country to suit their application to the conditions existing in another country, but in other cases the information needed will only be obtained by undertaking research into specific conditions in each country separately.

(b) Thus, for the broad development of a country, surveys should be made of the natural resources, their location and the possibilities of economic development

so that the data can be interpreted in terms of housing development and the establishment of new towns and industrial areas.

(c) For housing generally, it is necessary to undertake research and acquire information on the following aspects: minimum standards of accommodation applicable to the circumstances in a country, not only to meet essential human needs but also to ensure decent family living; number of families to be housed, their size and composition, their income, expenditure on essential needs and living habits, in order to obtain a reliable assessment of housing requirements and maximum rents that families can be expected to afford; housing densities, township layouts and soil conditions; structural performance requirements and testing techniques to ensure the safety and health of the occupants in relation to the possible effects of wind, hail, rain, fire, heat and cold; health and hygiene aspects of house design [3]; the quality and durability of materials to ensure that the structures will remain sound with little maintenance for a long period and will have a good market value; the problems of locally produced materials; and the development of new techniques and methods of construction.

(d) In South Africa, for instance, research on low-cost housing [4] contributed considerably to paving the way for a greatly accelerated country-wide activity in building large numbers of houses. In 1960, from Government funds, over 23,000 houses were built for the less-privileged peoples and over 157,000 during the 10-year period up to 1960. The research was organized by the National Building Research Institute on the basis of a large team effort working in close co-operation with many persons, organizations and housing authorities who had special knowledge of, or interest in, matters relating to housing and building. In this way a great deal of research was carried out within a period of a few years on aspects such as those mentioned above. The construction of experimental houses and even townships assisted in demonstrating the research findings and accelerated their application on a wide scale. It also initiated a process of further reducing the costs of materials and increasing production efficiency on building sites.

(e) All these activities were largely responsible for providing housing of very good standard at as little as half the cost that applied before the research was undertaken and for maintaining the costs at about these levels in spite of a continuous rise in costs in all other spheres of building. The advantages of the reduced costs have been three-fold:

(i) the Government has been able to house about twice as many families as previously for the same sum of money;

(ii) the loans are more secure, as two families now repay the sum previously borrowed by one; and

(iii) the tenant or home-owner has a better dwelling at a much reduced rental or repayment rate.

3. Research and techniques used in planning

(a) Materials resources

(i) In the broad issue, regional surveys of sources of raw materials for use by industries or for consideration of the possibilities of establishing industries should be made, and obviously the information

would have an important bearing on planning for the development of towns, including the siting of new towns.

(ii) In addition, however, it will always be important to make surveys of the possible sources of local materials which might economically be used to produce suitable building materials. In most less developed countries many manufactured building materials have to be imported and are therefore available only in limited amounts. The development of the production of suitable alternative materials at a competitive price will thus reduce expenditure on foreign goods and could at the same time provide employment and more earnings for people who would otherwise remain in the very low income bracket. As an example, investigations are being made in South Africa of the suitability and potential supply sources of clays for making bricks, hollow clay blocks, tiles and other building units.

(iii) Moreover, such research must stimulate studies to develop processes for the manufacture of materials, especially taking into account the lack of local skilled labour, and of the performance of the final products when exposed to local climatic conditions, including particularly high temperature, humidity and solar radiation. Examples of valuable work in this regard are the exploitation of the pumice deposits in the Rift Valley near Nairobi for light-weight concrete houses and the use of coffee husks as fuel for producing good quality burnt clay building units near Kampala.

(iv) Another interesting illustration is demonstrated by the work in South Africa which led to the establishment of an industry to produce slag cement from blast-furnace slag which was previously dumped as a waste material at some cost to the iron and steel manufacturer[5]. This "waste" material is now sold to the cement manufacturers. The slag produced in the country has an unusually high magnesia content and information available from overseas indicated that such slags would not produce a suitable product for use as cement. Nevertheless, a research study proved that a good cement could be manufactured. Further research is now in progress aimed at improving the quality of the cement and the methods of using it in building.

(v) In some countries reeds which grow along river banks could be used for producing good quality walls, roofs and ceilings. A simply operated machine is available which bundles reeds tightly together to form a continuous 'mat' of any desired thickness up to about 4 inches, and this 'mat' is easily cut to the required lengths. The material is reasonably rigid, can easily be fastened to framing, and takes a plaster finish satisfactorily.

(b) Soil mapping and soil investigations

(i) In many parts of Africa soil conditions are encountered which may lead to the cracking of structures erected on these soils[6]. This may affect the safety of the structures but in any case it means high repair and maintenance costs. Obviously, therefore, it would be desirable to avoid building on such soils or, if it cannot be avoided,

to design the foundations and structures so that they will remain safe and will require little maintenance. The problem soil conditions are:

a. the so-called "heaving" soils, which swell or otherwise change their volume, particularly after a building has been erected on them;
b. collapsing sands, which often adequately support a building while dry but quickly compress to a smaller volume when wet; and
c. sink holes, which may form suddenly, causing the ground surface level to drop anything up to several feet.

(ii) A relatively easy and low-cost technique for determining whether such soil conditions occur in fairly large areas where building development is proposed is that of soil mapping, effected by interpretation of the features observed in stereoscopic studies of aerial photographs. Recent studies in South Africa have shown that soil maps of an area can be produced rapidly and that the boundaries of the engineering soil types can be established with a satisfactory degree of accuracy. The next step is to carry out a field investigation, which includes taking soil samples and determining soil profiles by means of test pits, so that an indication may be obtained of the engineering properties of the soils and of their probable behaviour in relation to structures which might be built on them. However, some research might first be required on the soil types in a country to study their engineering properties and to establish what relationships these may have to soil behaviour and foundation design.

(iii) It is also necessary to carry out experiments on structural design for buildings that have to be built on unstable soils. There are many design methods that may be employed but the chief problem is to find one which is sufficiently economical for low-cost building.

(c) Socio-economic surveys

(i) Excellent survey techniques [7] have been developed to establish trends in average family sizes, and family size distribution; family composition in terms of parents, number and sex of children and of other persons who live with the family; preferred living practices and usage of space. Information based on such surveys of communities to be housed is vital to satisfactory design and planning of mass housing estates and it is strongly recommended that persons who know the people and conditions intimately should be trained to do this work.

(ii) The surveys should be designed to include information on family income and pattern of expenditure, thus making it possible to establish the minimum expenditure that different sizes of families must meet in order to provide the minimum necessities for a healthy, decent life. This comprises expenditure on food, clothing, fuel, cleaning materials, transport to work and medical care. By comparing this necessary minimum expenditure with the total legal earnings of a family it is then possible to assess the ability of the family to pay rent. Trends in rent-paying ability will therefore represent the measure for assessing the costs of the housing to be provided.

(d) Minimum standards of accommodation

(i) Minimum standards of accommodation must be related to the needs of both the individual and the family to make it possible to lead a healthy, decent, family life. Standards that apply in some countries may not be appropriate to others because of important differences in conditions, particularly climatic conditions. Space standards must be related to the necessary furniture and storage requirements and to the performance of all the functions required to live decently in the climate concerned. Furthermore, such design factors as ventilation, daylighting, roof and wall insulation and orientation require careful consideration when establishing minimum standards that are suited to the climatic conditions. The most satisfactory way of establishing such standards is for specialist study groups and research teams to collect all the relevant information and to assess it in relation to conditions in the country concerned.

(ii) The following minimum standards of accommodation were established in this way for South Africa (only the main features are given here):-

a. Room areas:

No. of persons accommodated	Type of dwelling	Room areas in square feet			
		Main bedroom	Bedrooms	Dining/ Kitchen	Living/ Sleeping rooms
2	Aged couple unit	-	-	70	110
2 to 3	One-roomed unit	-	-	70	118
4 to 5	Two-roomed unit	118	-	80	115
6 to 7	Three-roomed unit	118	94	90	120
8 to 9	Four-roomed unit	118	94	100	125
10 to 11	Five-roomed unit	118	94	100	130

b. The dining-kitchen, bathroom and store are not counted as rooms.

c. Bedrooms may be 5 sq. ft. less in area if built-in cupboards are provided.

d. In the kitchen 13 sq. ft. of shelving and 6 sq. ft. of working top, which may include the sink, are required.

e. Storage must be provided and if a coal stove is installed there must also be fuel storage space.

f. Individual latrine facilities must be provided for each dwelling unit.

g. A satisfactory supply of potable water must be available; and if this is supplied through stand-pipes, these must be not further than 500 feet from any dwelling.

h. Where bathrooms of a minimum area of 30 sq. ft. are not included in the dwellings, ablution blocks with hot water supply, providing 8 shower points and 8 washtubs for each 100 dwelling units, must be supplied.

i. Notes on ventilation, sizes of windows for sufficient daylighting and minimum ceiling to floor height of 8 ft. 6 in. average are also included.

(e) House plans and estate layouts

(i) Information based on socio-economic surveys and minimum standards of accommodation enables an intelligent approach to be made to the development of minimum house plans and of estate layouts, allowing for maximum economies to be achieved while meeting all the requirements. This work must be done in conjunction with cost studies on all aspects of building and town planning.

(ii) For instance, this procedure was applied on a thorough scale to mass housing in South Africa about ten to twelve years ago and a number of minimum house plans were produced which allowed the lowest costs in building the houses, whatever method of construction was used. Many thousands of houses have been built to these plans, or slightly modified versions of them, both in South Africa and other African countries, and possible suggestions for modifying the plans to allow further savings have been very few.

(iii) In the work of developing township plans, density studies provided the main criteria. They indicated that the necessary land for schools, clinics, playgrounds, sports fields, churches, shops etc. should be made available in the planning development. Rationalized street widths were recommended and proposals made on the safety of children going to school, the design of water supply, sanitation services and street lighting. Standards for minimum but adequate spacing around houses and other buildings were formulated and schemes were devised for landscaping and for the planting of trees so that they could be cared for by individual families. Up to the present the building of dwellings of more than one storey has not proved economical. However, as a result of recent developments in building and in providing services, the possibilities of including two- and three-storey dwelling units or terraced maisonettes were re-considered. Preliminary indications are that, although construction costs may still be a little higher than for equivalent single-storey dwellings, the difference may be offset by savings in the services.

(f) Quality and performance standards for structures

(i) The general practice for controlling the quality and performance of structures is to lay down regulations which specify what materials and methods of construction may be used. Such specification-type regulations, while being easy to apply, have a number of serious disadvantages particularly when applied to mass low-cost housing. The chief disadvantages are that they do not readily permit the use of new materials or of new and unorthodox methods of construction, developments in which can frequently introduce substantial savings in mass building costs.

(ii) The problem has been overcome in South Africa and some other countries by formulating, through research studies, minimum technical performance requirements for structures and by developing methods of testing or assessing the performance of structures[4]. These are designed to provide the following:-

a. Structural stability: the building should be able to withstand all forces which it can reasonably be anticipated that it might be exposed to during its economic life, e.g. wind pressures, the weight of workmen effecting repairs and the impact of furniture, kicking, slamming of doors etc. Other special forces, such as heaving soil conditions or hail impact, must also be considered.

b. Thermal performance: the building should be so constructed that the thermal environments which result inside the structure, will not be so severe as to affect adversely the health and working efficiency of the occupants.

c. Rain resistance: the construction should be such that, for the weather conditions to which it will be exposed, no more than a maximum allowable rain and dampness penetration to the interior will take place.

d. Durability: the durability of the materials and method of construction should be such that the maintenance costs are not unduly high and the other performance characteristics of the structure are not seriously affected during the economic life of the building.

e. Other requirements: the construction should be such that it does not constitute an unreasonable fire hazard, that it does not encourage the harbourage of vermin, and that it can easily be cleaned and disinfected.

(iii) This procedure readily allows the use of any materials and any method of construction provided only that the performance of the completed structure satisfies all the requirements. It thus ensures that the structures will remain satisfactory for many years and will maintain a good market value.

4. Operational Techniques

(a) Careful investigation and experimentation with both labour and building and site organization can lead to substantial savings in housing costs. In underdeveloped countries the lack of trained labour for building is usually a very serious handicap to progress on mass housing, and normal training facilities are inadequate to meet the situation.

(b) A system developed for training local labour rapidly on the job has proved to be highly successful in South Africa. It was found from tests that in many cases the man-in-the-street has a good natural ability to perform one building task or another, such as laying bricks, cutting timber, mixing or pouring concrete or making sand-cement blocks. For instance, by giving such a man the simple task of straightforward bricklaying between pre-laid corners in a wall and showing him the correct methods, it was found that after about one day's training he could satisfactorily undertake this task on his own. With a little more guidance he could usually increase his productivity to a fairly high level within a few weeks. After some months of doing this particular work on a succession of houses under construction he could generally be given instruction on the more difficult task of, say, forming the jambs against a door frame. In this way, teams of building operators, each repeating only one particular type of task on a series of structures, were rapidly trained while they were doing all the building themselves.

(c) This system of on-site training could be regarded as one of organized self-help. People build houses for themselves and their fellow-men while they are learning and they are paid for it at the same time. It provides a means of employment and of earning sufficient money to relieve the poverty in an otherwise very low income group.

(d) Even if this system is adopted, the possibilities of industrial systems of construction should also be investigated - such as the rapid fabrication on site of large wall or roof elements, the casting of whole wall sections on the ground and later lifting them into place, in situ casting of walls etc. Such methods often allow worth-while reductions in building costs.

5. Materials

(a) Studies and experimentation provide the best means of developing and using suitable materials for low-cost housing. A few illustrations are given here.

(b) Concrete building blocks are widely used in Africa for low-cost housing and general building, yet it is not a simple matter to produce good quality blocks or to build them into walls that will give satisfactory performance in all respects. Cracking in walls built of concrete blocks is frequently encountered and often leads to rain penetration, and safety and maintenance problems. Investigations have shown that the cracking is generally caused by dimensional changes in the blocks, resulting in mortar joints and even blocks themselves cracking; that the problem can only partly be overcome by improving the manufacture and curing of blocks; and that it is necessary to follow certain precautions when building them into a wall.

(c) To reduce the progressive shrinkage normally associated with cement products after they are manufactured it is necessary to use good quality materials; to use the correct proportion of cement for the particular materials used; to use the right water/cement ratio; and to cure the blocks under damp conditions for an adequate period after manufacture. Factors associated with any wetting and drying cause volume changes of the block, even long after the blocks have been made. For this reason the units should be quite dry when laid and not wetted as is common practice when laying bricks. The wall should be protected from rain during building and should also be allowed to dry out before it is plastered.

(d) The best compromise of procedures to suit a particular building project should be worked out by tests and experimentation. Furthermore, it might be necessary to find suitable waterproofing treatments to apply to the completed wall.

(e) Galvanized steel roofs are another common item in low-cost housing. At some stage, however, it becomes desirable to paint the roofs so that their life can be extended. In South Africa it was found that available commercial paints only had a durability of a few years. A study undertaken to develop new paint formulations that would provide effective protection to the steel for a very much longer period, was very successful in producing two formulations, one based on dehydrated castor oil and the other an acrylic type paint[8]. Suitable systems for painting timber exposed to the different climatic conditions in the country are now being developed.

(f) A further interesting study in progress is aimed at the production of low-cost timber houses using short lengths of locally grown timber. Quantities of short lengths of timber result from cutting logs in sawmills and there is practically

no market for them. Very few timber houses have been built in the country and consequently there is little experience of the problems involved and of the performance of such structures. The work therefore involves the development of suitable low-cost methods of construction and design aspects to ensure that the structures will meet the accepted minimum performance standards in relation to the climate.

6. Township Services

(a) Apart from studies to define design standards for the various services in a township and to indicate economical methods of providing the services, there is another important aspect which usually arises after a housing estate is completed. Economic rentals for the houses must cover the redemption and interest on the loan for the house plus the costs of engineering and other services in the township and the costs of administration. The portion due for the services etc. is often very much greater than that due for the structure itself and studies to reduce the costs of services could therefore be very fruitful in reducing the payment burden on householders and in over-all planning of the economies of housing.

(b) In under developed countries, methods of providing hygienic sanitation at low-cost usually present problems which are very difficult to solve. Among various possibilities, attention is being given in Africa to ponding as an economical and effective form of stabilization of waste waters for small towns and villages. The design of the ponds has been based on American practice which, unfortunately, is often inadequate for local conditions. A joint study carried out in South Africa and Rhodesia has now provided a theory and information on its application in practice which, it is hoped, will rationalize the design of such ponds[9].

Conclusions

(a) The rate of development in a country depends a great deal on the development of its human resources. Good housing and the provision of spaces and buildings for use in education, health services and recreation are therefore essential requirements in building up stable, healthy and industrious communities.

(b) In most of the countries of Africa, for instance, the pace of urban growth has continued to increase rapidly but has far outstripped the rate of planned development and has resulted in numerous slum areas. Consequently, the need for the provision of low-cost housing on a large scale is very urgent. The housing policy in many less developed countries has concentrated on accommodating the emerging middle classes of government officials, etc. resulting in relatively high costs for this partial attack on the problem. The solution demands a co-ordinated programme for housing on a national basis, based on factual information from research and experiment. Studies already made in some developing countries have indicated approaches which have led to successful procedures and techniques for obtaining valid solutions. It is suggested that these approaches might be usefully adopted in other under developed countries.

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